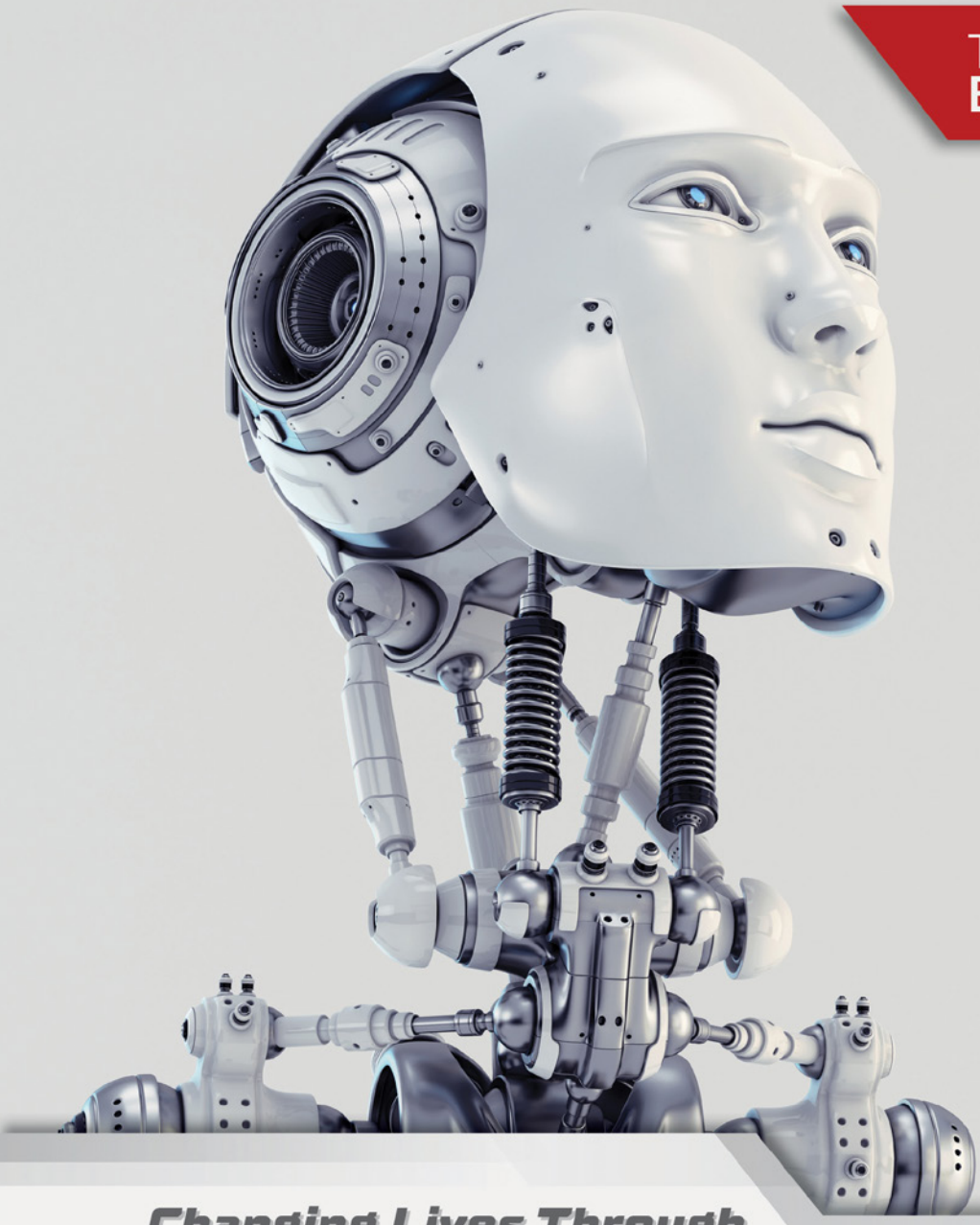
The Tech EFFECT



Changing Lives Through

ARTIFICIAL INTELLIGENCE

Stuart A. Kallen

VISIT…

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The Tech
EFFECT

Changing Lives Through

ARTIFICIAL INTELLIGENCE

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ReferencePoint Press®

San Diego, CA

© 2021 ReferencePoint Press, Inc.
Printed in the United States

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PO Box 27779
San Diego, CA 92198
www.ReferencePointPress.com

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LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Names: Kallen, Stuart A., 1955- author.
Title: Changing lives through artificial intelligence / by Stuart A. Kallen.
Description: San Diego, CA : ReferencePoint Press, Inc., 2020. | Series: The tech effect | Includes bibliographical references and index.
Identifiers: LCCN 2020007931 (print) | LCCN 2020007932 (ebook) | ISBN 9781682828397 (library binding) | ISBN 9781682828403 (ebook)
Subjects: LCSH: Artificial intelligence--Social aspects--Juvenile literature.
Classification: LCC Q335.4 .K35 2020 (print) | LCC Q335.4 (ebook) | DDC 303.48/34--dc23
LC record available at https://lccn.loc.gov/2020007931
LC ebook record available at https://lccn.loc.gov/2020007932

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The Promise and Perils of AI

The human brain is one of the most complex problem-solving systems on earth. Billions of interconnected nerve cells called neurons communicate with one another through chemical and electrical signals. Systems of neurons in the brain are behind every human achievement throughout history, from the construction of the ancient Egyptian pyramids to the maneuvering of the *Curiosity* rover across the surface of Mars.

Human neuron systems are also responsible for the creation of artificial neural networks, complex computing systems that mimic the memory and learning processes of the brain. Electronic neural networks are a type of artificial intelligence (AI) that can perform a number of tasks that traditionally required human effort. Computers equipped with AI can recognize speech, acquire and analyze images, play board games and video games, make medical diagnoses, and translate languages. Artificial intelligence has also been used in artistic endeavors, to write books and music and even make paintings.

The Promise of Machine Learning

In 2019 AI was used to grade 34 million student essays on high-stakes state and national tests in twenty-one states. Computers called robo-graders analyzed thousands of tests previously graded by humans and "learned" the difference between good and bad essays. After combing through this data, robo-graders were able to score essays based on

about seventy-five features, including spelling, grammar, coherence of argument, understanding of topic, and complexity of words and sentence structures.

neuron
A nerve cell that carries electrical signals within the nervous system

There is some debate as to whether artificial intelligence can grade student essays better than human teachers. Students have already figured out ways to game robo-graders; they simply copy long strings of text into their essays from the questions they are supposed to be answering. But technologists are hoping that advances in artificial intelligence will someday allow computers to solve problems much more complicated than grading essay questions. As Amy Webb, a professor and the founder of the Future Today Institute, explains:

> The great promise is that . . . these machines, alongside of us, are able to think and imagine and see things in ways that we never have before, which means that maybe we have some kind of new weird, seemingly impossible solution to climate change, maybe we have some radically different approach to dealing with incurable cancers. The wonderful promise is that machines help us in being more creative and using their creativity we get to better solutions.[1]

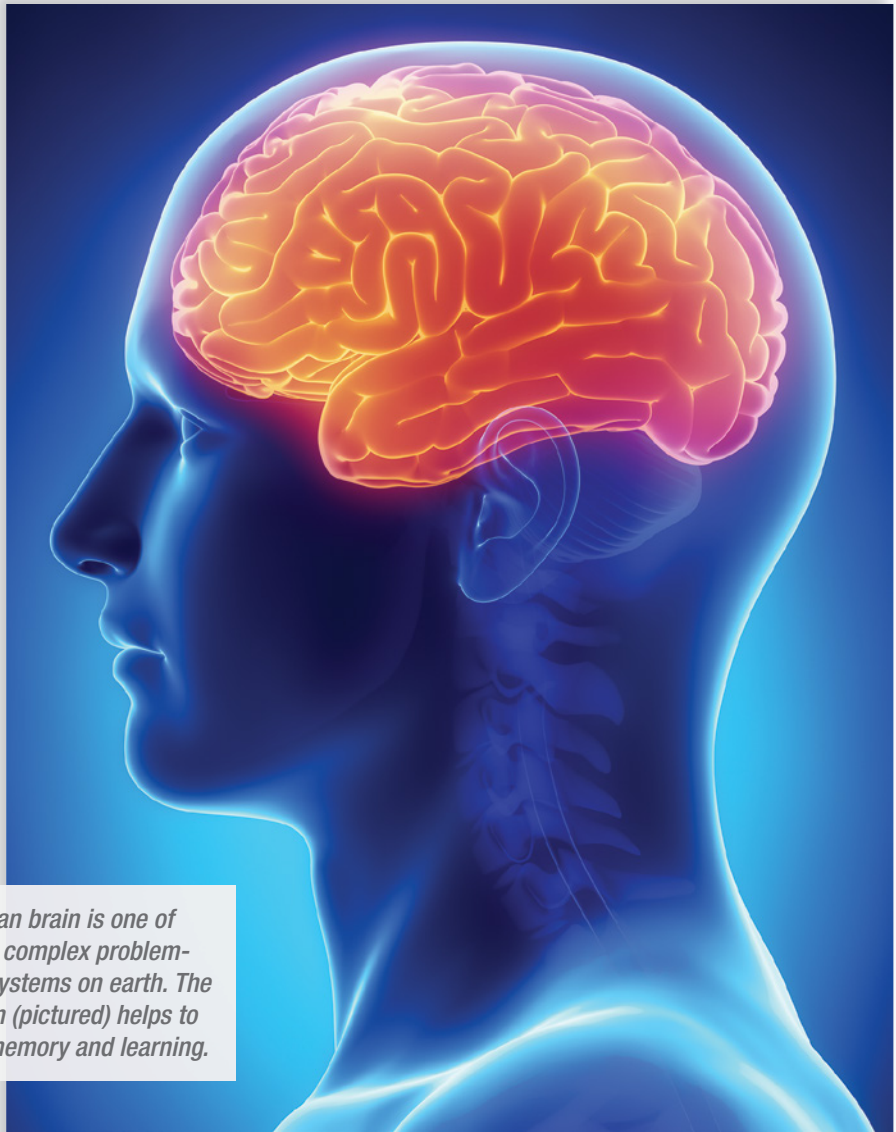
The Good and the Bad

Brad Smith, president of Microsoft, has compared recent advances in artificial intelligence to the discovery of electricity. Smith says that every business, government organization, and household will soon be as reliant on AI as they are on electric power. Companies like Amazon and Netflix are already using AI to anticipate the behavior of consumers through predictive algorithms that process vast amounts of data to determine what a customer might want next. Artificial intelligence is also being used to scour medical databases and predict individual patient outcomes. For example, AI

can accurately identify hospital patients who have a high risk of dying within forty-eight to seventy-two hours of admission. With this information doctors can take preventive steps to save lives.

While researchers seek new uses for AI every day, there are fears that the technology might create widespread economic disruption. A recent PricewaterhouseCoopers study found that about 38 percent of US jobs are at risk of being replaced by machines powered by artificial intelligence. By the late 2020s jobs ranging from truck driving to banking could be taken over by AI.

Another downside of AI is already being seen in China, where artificial intelligence is used to monitor the general public through



The human brain is one of the most complex problem-solving systems on earth. The cerebrum (pictured) helps to control memory and learning.

ubiquitous
Ever-present and appearing everywhere

ubiquitous surveillance cameras, facial recognition software, and mobile phone technology. Anyone who protests or even litters can trigger a rapid police response. Sophie Richardson, director of Human Rights Watch, maintains, "Most of the population there is being subjected to extraordinary levels of high-tech surveillance such that almost no aspect of life anymore takes place outside the state's line of sight. . . . Which language do you speak at home, whether you're talking to your relatives in other countries, how often you pray—that information is now being [vacuumed] up"[2] by authorities.

Just Beginning to Understand the Power of AI

Some warn that the growing use of AI will have consequences that people are just beginning to understand. Microsoft founder Bill Gates and Tesla chief executive officer (CEO) Elon Musk have both warned of an AI takeover. In their nightmare scenarios, computers and robots modify their own algorithms to create an intelligence explosion that humans are unable to control. Famed physicist Stephen Hawking predicted that creating intelligent machines might be "the worst mistake" in human history. "One can imagine such technology outsmarting financial markets, out-inventing human researchers, out-manipulating human leaders, and developing weapons we cannot even understand,"[3] he asserted. Currently, however, those who work with AI say that even the smartest machines are dumber than humans, while the benefits to society far outweigh any imagined negative consequence. As physicist David Deutsch puts it: "No brain on Earth is yet close to knowing what brains do in order to achieve any of that functionality"[4] in a machine. Whether artificial intelligence is good or bad, the biological neural networks in thousands of brains are finding new uses for the technology every day.

Teaching Machines to Learn

In 2013 an artificial intelligence company in London named DeepMind made headlines when one of its computers taught itself to play the Atari game *Breakout*. The game is simple; players use a paddle to bounce a ball at a wall of bricks, trying to make each brick disappear. The artificial intelligence computer, also called DeepMind, was able to accomplish this task through a self-education process called deep learning.

DeepMind was fed data from the game, such as images representing the bricks, the ball, and the paddle. The computer was not given any other information about *Breakout*, including the rules, how it is played, or even the ultimate goal of the game. After playing *Breakout* several hundred times, DeepMind learned to hit the ball into the bricks. By the six hundredth attempt, the machine was an expert, imitating strategies a human player might use to knock down one column of bricks before moving on to the next.

DeepMind's breakthrough moment in deep learning and artificial intelligence attracted the attention of Alphabet Inc., the parent company of Google. In 2015 Alphabet purchased the DeepMind company for $500 million. But in 2017 computer scientists at an AI tech company called Vicarious found limits to DeepMind's artificial intelligence. The scientists trained a similar system to play *Breakout* but made a slight change in the game; they added a col-

umn of bricks in the center that was unbreakable. While a human player could quickly analyze the situation and adapt new playing techniques, the AI computer floundered. Tech journalist Clive Thompson comments, "The seemingly super-smart AI could play only the exact style of *Breakout* it had spent hundreds of games mastering. It couldn't handle something new."[5]

Picking Out Flowers

Whatever its limitations, DeepMind is seen as the world's smartest artificial intelligence system. It is smart enough to instantly translate languages on Google's search engine, and it helps keep Alphabet's self-driving Waymo cars on the road. DeepMind, the company, also developed a computer program (or algorithm) called AlphaGo just so its AI could teach itself to play the board game Go. The company also created a successor program, AlphaZero, that allowed the computer's AI to understand and play chess.

algorithm
In computer programming, a set of instructions designed to accomplish a specific task

The artificial neural network that powers DeepMind uses a series of circuits that functions somewhat like the neural pathways in a human brain. The network can make sense of patterns even when details are missing. Thompson explains how the neural networks operate:

> Say you wanted a machine to teach itself to recognize daisies. First you'd code some algorithmic "neurons," connecting them in layers like a sandwich (when you use several layers, the sandwich gets thicker or deep—hence "deep" learning). You'd show an image of a daisy to the first layer, and its neurons would fire or not fire based on whether the image resembled the examples of daisies it had seen before. The signal would move on to the next layer, where the process would be repeated. Eventually, the layers would winnow down to one final verdict.[6]

When the process begins, the neural network is a blank slate, called a naive network. At first the computer analyzes hundreds of images, often confusing daisies with other flowers or vaguely similar images such as butterflies. But the machine quickly establishes a feedback loop between the layers that makes it more accurate. It discards links between layers that do not fit the pattern of a daisy while strengthening links between accurate images. Eventually, the layers of the neural network make decisions accurate enough to distinguish daisies from other images.

artificial neural network
A computing system that learns to perform tasks by analyzing vast amounts of data and finding patterns

The process that DeepMind uses to pick out daisies demonstrates how artificial neural networks differ from human intelligence. A computer can only train itself by sorting through a massive amount of data, thousands or even millions of pictures of daisies. The average seven-year-old can learn what a daisy looks like in a few seconds and pick out daisies growing in a field of flowers.

Machine Learning

With its artificial neural networks, DeepMind is the world's most advanced AI system. It is categorized as possessing artificial general intelligence (AGI). Artificial general intelligence is far more complex than what is called applied AI. Applied AI is used in specific applications, such as picking movies a Netflix customer might like.

The term *machine learning* is often associated with AGI. Machine learning researchers write algorithms that allow computers to discover patterns in data and classify them according to the elements they contain. The system uses the concept of probability. For example, if an image is circular and contains petals, it is probably a flower. If the petals are white and are attached to a yellow

center, it is likely a daisy. During this process the machine determines whether its decisions are correct or incorrect and modifies its approach when analyzing new images. This information can be used for decision-making and predictions. As business writer Bernard Marr explains:

> Machine learning applications can read text and work out whether the person who wrote it is making a complaint or offering congratulations. They can also listen to a piece of music, decide whether it is likely to make someone happy or sad, and find other pieces of music to match the mood. In some cases, they can even compose their own music expressing the same themes, or which they know is likely to be appreciated by the admirers of the original piece.[7]

Some aspects of machine learning have seen rapid improvements due to the huge amount of data generated and stored on the internet. Machines can comb through tens of millions of articles and books available online and learn to better understand and respond to natural language. This helps them analyze documents and answer questions. Machines are also learning about the natural world by analyzing billions of photographs of plants, animals, and natural scenery stored in Google and Facebook databases. The machine learning process is being applied to X-rays and other medical information to identify or predict health conditions in people. Marr explains, "Engineers realized that rather than teaching computers and machines how to do everything, it would be far more efficient to code them to think like human beings, and then plug them into the internet to give them access to all of the information in the world."[8]

machine learning
A subset of artificial intelligence focused on programming computers to learn tasks without relying on specific instructions from human operators

Images of animals are among the billions of photographs stored in Google and Facebook databases. Machines are learning about the natural world by analyzing photographs of plants, animals, and natural scenery.

Taking Tests

Advancements in machine learning can be seen in the improved test results achieved by artificial intelligence programs. In 2015 Microsoft cofounder Paul Allen offered an $80,000 prize to anyone who could devise an AI system smart enough to pass an eighth-grade science exam. Seven hundred computer scientists entered the contest. But the best system only achieved a 60 percent score, or a D minus. In 2019 an

AI program called Aristo correctly answered 90 percent of the questions on an eighth-grade science exam and 80 percent on a twelfth-grade test.

Aristo was created by the Allen Institute for AI in Seattle, founded by Allen himself in 2014. But Aristo's impressive scores could only be achieved on multiple-choice tests. If the test contained essay questions, Aristo would have likely failed; answering those kinds of questions requires logic and common sense. Peter Clark, senior manager for Project Aristo, explains the program's shortcomings:

> [Aristo] has difficulty dealing with hypothetical situations. For example, Aristo struggles with the following question: "If you pull the leaves off a plant, what would the result be?" A good answer would be that the plant would no longer be able to make its own food. But Aristo struggles with this question because it requires the system to create an imaginary world and imagine what would happen in that world.[9]

Teaching computers to use imagination and common sense is far more difficult than teaching them what daisies look like. Without human input, even the smartest computer does not understand that water is wet or a house is bigger than a horse. Tech journalist Cade Metz states, "Machine learning is very good at tasks like recognizing images and translating from one language to another. But because they rely on what is essentially statistical analysis, neural nets get things wrong. They identify the wrong photo. They choose the wrong word. They can't grasp the nuance of your requests. They travel down paths a human knows not to travel down."[10]

Teaching AI Common Sense

Aristo's inventors believe the program will have a range of uses, from keeping medical records to speeding up internet search engines. But if AI is to reach its full potential, it needs the ability to reason and put thoughts into context. That is something Stanford

University computer science professor Doug Lenat realized long ago. Lenat invented one of the earliest artificial intelligence programs, called Eurisko, in 1981. Lenat realized that AI applications would be limited unless the programs could understand basic concepts. This led him to assemble a team of researchers and philosophers in 1984 to begin compiling simple rules for computers. Many of the ideas are mundane, as one example states: a bat has wings and the wings allow a bat to fly. Because a bat can fly it can move from place to place. Researcher Ramanathan Guha explained in 2016, "It's all the things that a five-year-old knows. Computers still don't know that."[11]

Computer scientists at the Allen Institute are still working on the problem through their latest project, called Mosaic, which began in 2015. Mosaic researchers are occupied with perfecting an AI neural layer that will provide computers with commonsense reasoning. This led the scientists to create a set of questions that a thinking machine should be able to answer. For example, the list includes logic questions such as "If someone puts a shirt in a drawer, will it be there tomorrow?" and "If a person gets kicked in the shins, will that person be angry?"

Mosaic scientists soon came to understand that they needed outside help to think of the countless simple concepts that are not understood by even the smartest machines. The institute turned to Amazon Mechanical Turk (MTurk), a crowdsourcing website for businesses. Offered by online retailer Amazon as part of its web services, MTurk hires freelance workers, called "Turkers," to perform tasks that computers are unable to do, such as identifying hateful content in videos or writing product descriptions.

Computer scientist Yejin Choi engaged the Turkers to describe the intent or emotions that are implied by a person's actions. Choi picked simple phrases like "Oren cooked Thanksgiving Dinner"[12] and asked hundreds of Turkers to describe Oren's intent. She used the answers to train an AI system to infer Oren's thoughts and emotions. The system worked only about half the time, but it did provide some good answers. For example, the machine

Coding Common Sense

The work of computer science professor Doug Lenat exemplifies the difficulty of teaching machines to reason. In 1981 Lenat created Eurisko, one of the first AI software programs. He used the program in a tournament to win a starship combat scenario in the science fiction role-playing game Traveller. Eurisko won two years in a row, handily defeating human opponents. Lenat recognized that Eurisko could win by simply analyzing more data and more possible outcomes than humans, but to reach true intelligence, computers would need to possess common sense.

In 1984 Lenat gathered a team of engineers and philosophers to write digitized rules that reflect human commonsense reasoning. By 2019 they had been at it thirty-five years, coding nearly 25 million entries into a computer engine called Cyc. Many of the rules are simple: "You can't be in two places at the same time," "You can't pick something up unless you're near it," and "When drinking a cup of coffee, you hold the open end up." The Cyc database also spells out obvious observations such as "all trees are plants" and "a moose is not a mouse." From these entries, Cyc can identify patterns to make decisions based on its commonsense programming.

Cyc is a unique program; nothing like it exists anywhere else. Its analytic capabilities are used by the Cleveland Clinic to develop a natural language query system for the clinic's biomedical information. And the National Security Agency has used the program to identify terrorist threats in international communications data.

Quoted in Cade Metz, "One Genius' Lonely Crusade to Teach a Computer Common Sense," *Wired*, March 24, 2016. www.wired.com.

sometimes inferred that Oren cooked Thanksgiving dinner to impress his family or feel loved. Choi also had Turkers analyze the physical relationship between thousands of common objects. For example, if Oren throws a ball, the ball must be smaller than Oren. Because computers cannot make such assumptions yet, they must be fed huge numbers of logical assumptions to draw upon when making decisions.

In 2018 Choi and eight other institute researchers used their crowdsourced information to assemble a database called ATOMIC: An Atlas of Machine Commonsense for If-Then Rea-

soning. The basic concept of an *if-then* scenario is explained in a paper published by Choi and other researchers: "If X pays Y a compliment, then Y will likely return the compliment."[13] The atlas uses if-then situations in nine different settings. These include the mental state inferred by an event (X pays Y a compliment because she wants to be nice); events created by the initial event (Y smiles after X pays a compliment); and personality traits (X is a caring person). ATOMIC includes more than 300,000 events associated with 877,000 if-then combinations. According to the research paper, "Experimental results demonstrate that neural networks [using the ATOMIC database] . . . can anticipate the likely causes and effects in rich natural language descriptions. . . . We also present neural network models that can learn to reason about previously unseen events to generate their likely causes and effects."[14]

Built-In Bias

Most research into AI is focused on teaching machines to think like humans when they identify objects and use language. But humans are limited in their thought processes, and sometimes these limitations can create flawed artificial intelligence systems. For example, in 2015 Amazon began developing an AI program to recruit new employees. Over a three-year period, Amazon machine learning specialists fed the data to the AI program. The AI analyzed thousands of résumés submitted to Amazon over a ten-year period by the company's most talented employees so that the computer could learn what skills marked a successful Amazon employee. The program then crawled through millions of résumés posted to job websites to identify and rate potential candidates interested in the company's open positions. One of the unnamed programmers explained the thinking behind the program: "Everyone wanted this holy grail. They literally wanted it to be an engine where I'm going to give you 100 resumes, it will spit out the top five, and we'll hire those."[15] But this was not the result.

An Amazon worker sorts packages at a warehouse in France. To help recruit new employees, Amazon developed an AI program that analyzed thousands of résumés of the company's most talented workers to learn what skills marked a successful employee.

While searching for an efficient way to hire new workers, machine learning specialists unwittingly built a flaw into the AI recruiting tool. The tech industry is dominated by men, and around 70 percent of the résumés Amazon received were submitted by men. After analyzing this data, the AI recruiting tool taught itself that male candidates were preferred. The algorithms focused on verbs more commonly used on the résumés of male engineers, such as *executed* or *captured*. The AI program penalized résumés that contained terms like *women's chess club* or *women's college*. Amazon tried to change the program to make it more gender neutral, but there were fears that it would devise other methods of screening potential workers that were discriminatory. Amazon quietly disbanded the team working on the project in 2018.

Using AI to Sentence Felons

The US judicial system has used an AI program called COMPAS to assess the character of convicted felons and predict their future behavior. *COMPAS* is an acronym for Correctional Offender Management Profiling for Alternative Sanctions. Judges and probation officers use COMPAS algorithms to assess the likelihood of a criminal defendant committing more crimes upon release. Those with the greatest risk are often given longer sentences or denied parole.

COMPAS analyzes data such as type of offense and a person's age, prior convictions, and employment status. Each defendant is given a simple score. Those with high scores were given longer sentences, while those with lower scores were deemed least likely to reoffend and given shorter sentences or sent to drug treatment programs. When professors Megan T. Stevenson and Jennifer L. Doleac at George Mason University analyzed COMPAS in 2019, they found defects in its algorithms. One flaw concerned awarding scores based on a person's age. While raw data shows that younger people tend to commit more crimes, COMPAS programmers unfairly gave much higher scores to young defendants simply because of their age. Judges often exhibit more mercy when dealing with young people and tend to give them second chances, but when defendants younger than twenty-three were processed through COMPAS, they were four percentage points more likely to be jailed. Their sentences were also 12 percent longer than older offenders. These findings have not deterred judges in thirty states from consulting COMPAS when making sentencing decisions.

The Amazon project reinforces the old saying among computer scientists: garbage in, garbage out. When flawed data is entered into a program, the output will be flawed. Despite astonishing progress in machine learning in recent years, AI can still inherit the shortcomings of the people teaching computers to think. Researchers are trying to counter this problem by giving AI more independence and less human supervision.

Whatever the deficiencies associated with machine learning, AI is playing an increasingly larger role in the daily lives of most people. Many of the researchers and programmers developing these electronic brains understand the need to create AI that does not reflect bias. Computer scientist Viraj Kulkarni concludes, "We have a unique opportunity. For the first time in history, we have a real shot at building a fair society that is free of human prejudices by building machines that are fair by design."[16] Like Kulkarni, many programmers hold on to this ideal as they push AI to learn and reason better.

CHAPTER TWO

Everyday Applications of AI

In 2013 venture capitalist Aileen Lee coined the term *unicorn* to define a start-up tech company with a value of $1 billion or more. Lee chose the name of the legendary unicorn because it represented something so rare as to be almost mythical. Artificial intelligence has knocked down a lot of long-held assumptions since the mid-2010s, and the unicorn company was one of its fatalities. In 2020 there were fourteen unicorns in China that were less than five years old. These companies all attained their $1 billion valuation by creating products and services centered on AI technology. To put that number in perspective, in 2014 Google bought the company DeepMind, which invented artificial neural networks, for around half a billion dollars. And at that time there were only thirty-nine unicorns in the world.

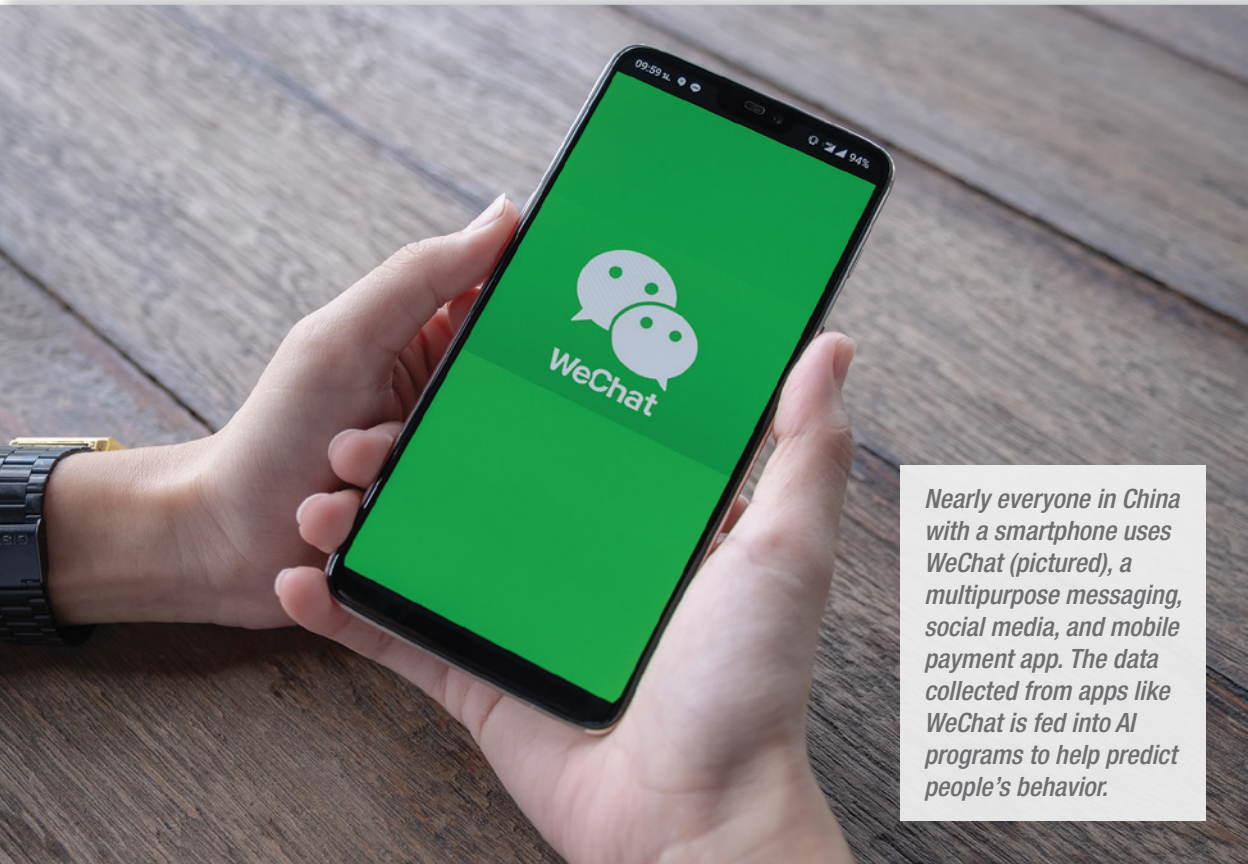
The proliferation of Chinese unicorns can be traced to a plan implemented by China's president Xi Jinping. In 2017 Xi told an audience of foreign diplomats that China would catch up to the United States in artificial intelligence research by 2025 and lead the world by 2030. In the two years that followed, start-ups in China plunged into AI implementation so rapidly that it gave birth to all those unicorns while completely transforming Chinese society.

With a population of nearly 1.5 billion, China has over 1 billion smartphone users—around four times more than the United States. Nearly everyone in China uses WeChat, a

venture capitalist
An investor who provides money to a promising company in exchange for a stake in the venture or project

super-app that combines aspects of Facebook, WhatsApp, Venmo, Uber, and other services. Data is the digital lifeblood for artificial intelligence, and the information gleaned from 1 billion cell phones has fueled the unicorn boom. AI researcher Kai-Fu Lee explains:

> [In China] there are 50 times more mobile payments than the U.S. There are 10 times more food deliveries, which serve as data to learn more about user behavior, than the U.S. Three hundred times more shared bicycle rides, and each shared bicycle ride has all kinds of sensors submitting data up to the cloud. We're talking about maybe 10 times more data than the U.S. . . . The more data, the better the AI works. . . . So in the age of AI, where data is the new oil, China is the new Saudi Arabia.[17]



Nearly everyone in China with a smartphone uses WeChat (pictured), a multipurpose messaging, social media, and mobile payment app. The data collected from apps like WeChat is fed into AI programs to help predict people's behavior.

When data is fed into deep learning algorithms, computers predict people's behavior in a fairly accurate manner. Chinese lenders use deep learning programs to provide short-term, small loans in a matter of seconds. Customers enter their name in an app and fill in an amount and the length of time they want to borrow the money. An AI program analyzes over five thousand personal data points, and if the loan is approved, money is instantly deposited in the borrower's digital account. The e-commerce giant Alibaba, known as the Chinese Amazon, lends money through a system called MYbank, which offers what it calls 3-1-0 loans. It takes three minutes to apply and one second to get approved, and zero humans are involved.

While a regular bank only analyzes around ten features when making a loan, the AI lending system judges creditworthiness using data no human previously had access to or even considered. For example, the data indicate that people who let their cell phone batteries run down more often have a better chance of defaulting on loans than those who keep their phones charged.

Smile to Pay

Perhaps the biggest breakthrough in Chinese AI technology is in the field of facial recognition payment systems. Credit cards were never popular in China, and many stores do not even take cash. However, Chinese consumers can pay for goods at supermarkets, fast-food restaurants, gas stations, and other retail outlets with their cell phones. Facial recognition technology identifies them in 100 milliseconds, or one-tenth of a second. Their face is linked to their digital payment system, and goods are purchased without reaching into a pocket or purse. Alibaba calls its system Smile to Pay, while WeChat uses a system called Frog Pro.

The Chinese government is an authoritarian dictatorship that is regularly criticized for using facial recognition to monitor the movements of political dissidents and others. But average consumers

seem to have few qualms about the technology. According to shopper Zhang Liming, "It's convenient because you can buy things very quickly. It's different from the payment in the traditional supermarket, in which you have to wait in the checkout line and it's very troublesome."[18]

The technical term for facial recognition technology is *biometric artificial intelligence*. Biometrics are unique defining human characteristics, such as facial shape and the iris patterns in the eye. Some technology uses skin texture analysis to record the location

biometrics
Measurements of the body and various unique characteristics such as fingerprints and facial patterns

A young woman uses facial identification technology to make an online payment at a technology expo in China. Facial recognition payment systems allow Chinese consumers to pay for goods at supermarkets, gas stations, and other retail outlets with their smartphones.

of freckles, veins, moles, wrinkles, and other features. Biometric algorithms compare photos to the details of an individual's face that include the size, shape, and position of the eyes, nose, cheekbones, and jaw. Other biometrics focus on a person's body shape and gait—the movements he or she makes when walking. Biometric systems record these characteristics with 3-D sensors. The information is fed into massive databases containing billions of ID photographs kept by Chinese authorities. Gait recognition can identify people from up to 165 feet (50 m) away, even if their backs are turned or their faces are covered. With these precise identification methods, Chinese retailers are making cash and credit cards obsolete.

Intelligence

By comparison, the biggest tech companies in the United States earn profits by using artificial intelligence to mine trillions of pieces of user data for advertising purposes. Amazon uses deep learning programs to recommend products and to figure out which goods to stock in fulfillment centers. Music services like Spotify use AI to analyze listening habits and provide users with suggestions for new releases. Facebook uses AI to gather data from the billions of photographs people post on the site. When people post pictures from weddings, vacations, work, or other settings, Facebook algorithms predict the future behavior of individuals in photos to target them with ads to match that predicted behavior. Newlyweds, for example, might be interested in buying a home or furnishing one.

Privacy advocates criticize tech giants for not disclosing the extent of their data-mining activities. But those who support such practices point out that data mining provides income to social media companies, which allows them to offer their services for free. Additionally, defenders say AI helps make the online world safer. Twitter and Instagram use deep learning algorithms to eliminate racist and violent content and stop cyberbullying. Facebook would barely exist without AI systems that perform 293,000 sta-

China's AI Transformation

Visitors to China in the early 2020s were often amazed at how quickly artificial intelligence had been integrated into all aspects of society. Tourists landing at the Shanghai airport could scan their passports into a machine, which greeted them in their native language. When travelers checked in to a hotel called FlyZoo, facial recognition systems automatically opened the doors to their rooms. Robots provided room service and even mixed drinks in the bar. E-commerce purchases were delivered by driverless delivery robots or drones. Shoppers who visited one of the numerous Hema grocery stores found AI-driven robots packing everything from toothpaste to peppers for online consumers. At the store's lunch counter customers used their phone to order meals that were then delivered by little white robot waiters. Those who wished for an after-lunch workout at the gym followed exercise instructions on a video screen embedded in the floor. No human trainers were employed.

In some places, Chinese drivers found traffic flowing smoothly thanks to video cameras and sensors embedded in roads that synchronized stoplights. Those who violated traffic laws could expect a quick e-ticket from police cameras running an AI program that tracked every vehicle and license plate. Critics call such systems automated authoritarianism, but surveys in China show that people are unconcerned about the lack of privacy. Or if they are concerned, they keep their thoughts to themselves. In fact, many people expressed pride in China's skyrocketing success as a tech power that has used artificial intelligence to transform the nation.

tus updates every minute. Customers also benefit when digital assistants like Apple's Siri, Google Assistant, and Amazon's Alexa use AI to help them check their schedules, conduct web searches, and send commands to other digital devices.

Teaching Cars to Drive

While online companies gather information about trillions of web searches, photo uploads, and other user data, the electric car company Tesla is using AI for crowdsourcing. When someone drives a Tesla down the road, the car sends data directly to the

A driverless Tesla navigates a country road using its autopilot feature. Teslas have built-in systems that allow them to learn how to steer by collecting data from human drivers.

cloud concerning the driver's hand placement on the wheel, rate of acceleration and braking, and other information. Artificial intelligence converts this massive, ever-changing database into maps that show traffic speed over a stretch of road and locations where drivers take evasive actions to avoid hazards. This allows Tesla to send real-time warnings to drivers to ensure they have safer trips.

Tesla vehicles are able to form networks with other Teslas nearby to share local information. AI is also used to monitor the electrical and mechanical systems of cars. If problems are detected, the AI can automatically repair some problems by updating software or taking other actions internally.

All Teslas ever manufactured have built-in systems that allow them to be operated autonomously. The company plans to use the crowdsourced driver information in the future to enable every Tesla to drive itself. The AI system was created in partnership

with the hardware maker Nvidia. On its Facebook page, Nvidia states, "In contrast to the usual approach to operating self-driving cars, we did not program any explicit object detection, mapping, path planning or control components into this car. Instead, the car learns on its own to create all necessary internal representations necessary to steer, simply by observing human drivers."[19]

autonomous
Independent of human control

Trucking Without Truckers

While autonomous cars might be beneficial to average drivers, the technology will disrupt the lives of taxi drivers, delivery persons, and others who work behind the wheel. And some are predicting that millions of truck drivers will lose their jobs in the coming decades as humans are replaced by AI-powered machines.

In 2018 a San Francisco company called Embark Trucks completed the world's first coast-to-coast journey of an autonomous truck. By 2020 Embark was using driverless semis to transport refrigerators down Interstate 10 between the Frigidaire factory in El Paso, Texas, and a distribution center in Palm Springs, California. Embark was cofounded in 2015 by Alex Rodrigues, a nineteen-year-old robotics prodigy. Rodrigues started building championship-winning competitive robots when he was eleven. He created an autonomous golf cart in his parent's garage in 2009 at age fourteen. At that time the autonomous vehicle industry was in its infancy. Rodrigues's work caught the eye of venture capitalists who financed Embark.

Companies that adopt self-driving semis will save time and money. For safety reasons, human truck drivers are only legally allowed to drive eleven hours a day. With these safety regulations in place, a 2,400-mile (3,862 km) coast-to-coast trip takes five days. An autonomous truck can cover the same distance in two days. And as Rodrigues says, there is also a human benefit to the technology. "We can build a truck that's 10 times safer than a human driver," he says. "When we talk to regulators especially,

everyone agrees that the only way that we're going to get to zero highway deaths, which is everyone's objective, is to use self-driving [vehicles]."[20]

To move safely down the road, a self-driving machine relies on billions of bits of data provided by its Global Positioning System (GPS) unit, video cameras, cloud-based maps, and numerous sensors that detect objects, lane markings, and the position of other vehicles. AI researchers create highly detailed software programs that help the car navigate through nearly every type of situation. Data scientist Fei Qi explains, "We must somehow figure out how to develop algorithms that master Perception, Localization, Prediction, Planning, and Control."[21] Perception helps the car "see," localization lets it know exactly where it is, prediction helps it identify potential hazards, and planning and control keep the car moving safely forward. Mastering these will help convince the public that such vehicles are safe.

None of this would be possible without the latest breakthroughs in deep learning. As Rodrigues said in 2019:

> A lot of people don't know this, but it's remarkably hard for computers, until very, very recently, to do even the most basic visual tasks, like seeing a picture of a person and knowing that it's a person. And we've made gigantic strides with artificial intelligence in being able to do scene-understanding tasks, and that's obviously fundamental to being able to understand the world around you with the sensors that you have available.[22]

Advances in deep learning allow a robotic brain to constantly collect data, interpret it, and update its algorithms. With deep learning a machine can independently make informed decisions by taking real-life driving experiences, turning them into programmable information, and improving its understanding of the real world.

Eliminating Trucker Jobs

From 2015 to 2017, large trucks were involved in almost eleven thousand fatal crashes in the United States, killing 12,230 people. Promoters of self-driving semitrailers believe that autonomous systems, which never get tired or distracted, can eliminate most if not all of those fatalities. Autonomous technology includes systems for collision avoidance and stability control.

While there is some disagreement over whether autonomous trucks are safer, the trucking industry is plowing ahead with plans to get self-driving trucks on the road as soon as possible. Basic economics is behind this push. Trucking industry profits were around $740 billion in 2020. One-third of that amount—$246 billion—went to labor costs. If the industry could eliminate truck drivers, it could save billions. Additionally, driverless trucks operate twenty-four hours a day, while wheel time for human drivers is limited to eleven hours a day by federal law.

In 2019 the *Los Angeles Times* predicted that nearly 2 million jobs would be lost to self-driving trucks within a decade. However, the American Trucking Associations trade group says it will take twenty to twenty-five years before fully autonomous trucks replace human drivers. Whatever the case, autonomous trucks are already making deliveries in California, Texas, and elsewhere. There is no question that fewer people will be driving trucks for a living.

Unemployment or Enlightenment

Embark is among a number of tech companies working to make human truck drivers unnecessary. Daimler Trucks, Waymo, and start-ups like TuSimple and Plus.ai are investing millions in autonomous systems. Tesla is working on an electric autonomous truck that will drastically reduce fuel costs while limiting negative environmental impacts. And companies like Uber are developing self-driving taxis. In 2020 General Motors rolled out the Cruise Origin, an electric self-driving robo-taxi that lacks pedals and a steering wheel.

While artificial intelligence has already been integrated into many aspects of daily life, the technology is still in its infancy.

As AI becomes more advanced, taxi drivers, truckers, and even stock traders, bankers, and lawyers might be looking at a bleak employment picture. But researcher Kai-Fu Lee remains optimistic: “If we do a very good job in the next 20 years, AI will be viewed as an age of enlightenment. Our children and their children will see . . . that AI is here to liberate us from having to do routine jobs and push us to do what we love and push us to think what it means to be human.”[23]

CHAPTER THREE

AI Medical Innovations

Breast cancer kills more than forty-one thousand women annually in the United States. But early detection and treatment of breast cancer can help prevent fatalities. This prompts around 33 million women to have mammograms (breast X-rays) every year to screen for the disease. However, mammograms are not always accurate. According to the American Cancer Society, mammography misses about 20 percent of breast cancers. Additionally, false positives are common—a woman is told she might have breast cancer when she does not. In addition to inducing stress, a false positive might result in an unnecessary biopsy, a procedure in which a tissue sample is extracted by a physician and analyzed in a laboratory for signs of cancer.

mammogram
An X-ray picture of the breast used to detect early signs of breast cancer

Regina Barzilay understands the uncertainties surrounding breast cancer only too well. Barzilay is a breast cancer survivor. She is also a professor at the Massachusetts Institute of Technology (MIT) who runs the MIT Artificial Intelligence Laboratory. When she was first diagnosed with the disease in 2014, Barzilay wondered why her cancer could not have been detected earlier: "I was really surprised that the very basic question that I asked my physicians, which were really excellent physicians . . . they couldn't give me

answers that I was looking for."[24] Barzilay's search for answers led her to develop an early detection system for breast cancer that uses artificial intelligence and deep learning.

Finding Cancer Early

Doctors who diagnose diseases by looking at mammograms and other X-rays are called radiologists. When searching for breast cancer, radiologists compare a woman's previous mammograms with her new ones. The doctors look for specific signs, including small white spots called calcifications and larger abnormalities called masses. When calcifications are very tiny, they can be overlooked by a radiologist. According to Constance Lehman, director of breast imaging at Massachusetts General Hospital (MGH), "There are many radiologists who are reading mammograms who make mistakes, some well outside the acceptable margins of normal human error."[25] By the time the spots grow large enough to be recognized as cancerous, the patient might need to undergo harsh procedures such as radiation treatment or chemotherapy, or removal of the breast (mastectomy). But as Lehman says, "when we find it early, we cure it, and we cure it without having the ravages to the body when we diagnose it late."[26]

pixels
Short for *picture elements*; tiny spots of light that make up digital images

Lehman worked with Barzilay to incorporate AI in the search for detecting early signs of breast cancer. The researchers accessed thousands of MGH mammograms that showed cancerous growths. These images, along with medical records, were scanned into an AI program. Like all digital images, scanned mammograms consist of millions of tiny dots called pixels. Barzilay explains how AI can interpret pixels to detect breast cancer at a very early stage:

> [An AI program] can take hundreds of thousands of images where the outcome is known and learn, based on

how pixels are distributed, what are the very unique patterns that correlate highly with future occurrence of the disease. So instead of using human capacity to recognize [patterns] . . . which is inherently limited by our cognitive capacity and how much we can see and remember, we're providing [the] machine with a lot of data and mak[ing] it learn this prediction.[27]

Not only was artificial intelligence better at detecting breast cancer cells, but the system also could predict whether a patient might develop the disease within five years. While radiologists will continue to play an important role in breast cancer diagnoses, AI enhances their performance. Computers can flag mammograms that need further inspection by radiologists while also making note of those that appear to provide false positives. However, Lehman predicts that AI might one day eliminate the need for radiologists. "We're

A radiologist reviews the image produced by a mammography X-ray scanner during a patient visit. AI helps radiologists identify mammograms that need further examination or those that may have produced a false positive.

onto something," she says. "These systems are picking up things a human might not see, and we're right at the beginning of it."[28]

Digitize and Diagnose

Artificial intelligence works best when it can access vast amounts of data, such as X-rays, medical histories, patient outcomes, and research papers. That is why some consider AI to be a revolutionary technology that will change the face of the health care industry. *Forbes* magazine predicts that the market value of AI in health care will reach $87 billion in 2030. And this number is only expected to grow as researchers introduce innovations in drug development, surgery, hospital operations, and data management, or as data scientist Terence Mills categorizes it, "digitization, engagement and diagnostics."[29]

The terms *digitization* and *diagnostics* refer to the process of using AI to comb through patient data, as Lehman and Barzilay have done to detect breast cancer. Google is using its DeepMind system in a similar manner to detect over fifty types of eye disease by analyzing biometric eye scans. The system is a thousand times faster than human doctors and has an 87 percent accuracy rate.

Digitization is also being used to customize medication and recovery routines for individual patients. This field, called precision medication, relies on digitizing millions of medical records that describe treatment histories, lab results, allergies, hereditary traits, and lifestyle factors such as smoking or exercise routines. Most of this information currently sits in filing cabinets or on computer hard drives. But AI precision medication algorithms can compile this data and use it to help doctors prescribe the best medicine for an individual based on the outcomes of millions of others who have similar physical characteristics and diseases.

Precision medication is promising because doctors are not always right when it comes to prescribing medicine. According to a study of the US health care system by the *British Medical Journal*,

The Chinese Robot Dentist

The average dentist might not worry about being replaced by a machine. But in China a robotic dentist has been operating autonomously on patients since 2017. The robot's first procedure involved installing two dental implants in a woman's jaw. The artificial teeth were created using 3-D printer technology. They were fitted into the patient's mouth by a robotic apparatus. Medical staff positioned the robot so it could properly implant the teeth. Before the robot began drilling, it used artificial intelligence to map the patient's mouth in great detail. During the procedure, the robot dentist relied on AI to recognize the patient's level of pain based on elevated blood pressure and increased respiration.

The robot dentist was developed for two reasons. Over 400 million Chinese are in need of new teeth. And dentists make a large number of errors when implanting teeth in the small space within the mouth. After its initial success, the robot was taught to perform other work, including filling cavities, cleaning teeth, extracting teeth, and installing crowns and bridges. Robot dentists are also employing artificial intelligence applications to scan X-rays and identify problems like tooth decay and bone loss. Programs using predictive analytics scan patient histories and warn of future problems.

one in twenty Americans, or 12 million people, are misdiagnosed every year. This means doctors might say patients have an illness or disease they do not have and prescribe drugs that are not necessary. The study says that half of these errors pose a substantial patient safety risk.

Surgical Robotics

The engagement category of Mills's slogan concerns the field of robotics. While some might squirm at the idea of being operated on by a robot, most surgical robots augment the work of surgeons. The machines perform tasks with extreme precision, eliminating the slight tremors of the human hand. As Mills points out, "Surgical robots operate with a precision rivaling that of the best-skilled

A medical team performs a minimally invasive surgery on a patient using a da Vinci medical robot. The da Vinci system gives doctors the ability to control surgical instruments via a computer console.

surgeons. A Chinese robot dentist equipped with AI skills can autonomously perform complex and delicate dental procedures."[30]

Robotic surgeons are nothing new. The Japanese company Kawasaki marketed a robot in 1985 that could insert biopsy needles more accurately than a surgeon, even into tumors located deep within the brain. This robot was an industrial machine that was modified to perform medical procedures. In the early 2000s the da Vinci surgery system was introduced for laparoscopic surgery, operations performed in the abdomen or pelvic area using small incisions and fiber optics. The da Vinci system gave surgeons the ability to control surgical instruments indirectly via a console.

While earlier surgical robots were able to perform a few basic procedures, the advent of artificial intelligence has led to a boom in medical robotics. There are now more than a dozen types of surgical robots in use, and according to *Robotics Business Review*, at least thirty-six new surgical devices will be entering the market by 2025.

A machine that converts a surgeon's movements into movements by a robotic arm is called Surgeon Waldo, or simply Waldo. The name comes from a robotic doctor described in a 1942 science fiction story by Robert A. Heinlein. However, Waldos are far beyond anything that could have been imagined in the 1940s. These machines have enhanced 3-D vision that is more accurate than the human eye, as well as extreme touch sensitivity. Waldos learn by collecting data as a surgeon performs procedures with the robotic arm. The data is turned into complex algorithms that determine patterns within the procedures to improve accuracy. This helps surgeons make smaller incisions and perform more precisely in small areas.

Other machines, known as programmable automatons, are used to destroy cancerous tumors. A programmable automaton called the CyberKnife uses deep learning to create a digital map of the patient. The robot can calculate, with extremely high accuracy, the position of a tumor within the body. The CyberKnife fires a precisely targeted dose of radiation through the skin to destroy the tumor. This allows patients to avoid invasive surgery. And unlike the ravages to the body caused by chemotherapy treatment, there are few side effects when programmable automatons are used.

While most medical robots are used to assist doctors, a Chinese company called iFlytek is building robots to replace doctors. In 2017 an AI-powered robot named Xiaoyi passed China's national medical licensing exam, with a high score of 456 points out of 500. The iFlytek robot was designed to capture and analyze patient information and provide diagnoses and medication. China has a severe shortage of doctors, especially in rural areas. iFlytek plans to use robotic doctors to help more people access quality medical treatment. The robots can also be used to train and aid human doctors.

Machine Learning Nurses

In Japan humanlike robots are used as nurses and health care workers in elderly patients' homes. A large machine called the Robot Nurse Bear helps these patients, who often have limited

A Recipe for Living Robots

In 2020 a research team of scientists and roboticists at the University of Vermont (UVM) created a new life-form by combining artificial intelligence with biology. The creatures, called xenobots, are made up of around 750 living cells and are less than 1 millimeter (0.04 in) long. Xenobots look like tiny blobs of pink popcorn. They do not have gears, wheels, or electrical connections like traditional robots. Scientists refer to them as biological robots because they were designed by a supercomputer running a complex AI program.

The UVM supercomputer tested thousands of potential designs, using deep learning to reject weak ideas while refining strong ones. The AI program created a xenobot "recipe" that consisted of skin and heart muscle cells taken from frog embryos. Biologists followed the recipe in exacting detail, using micro-medical tools and electrodes to cut and join the cells in a specific order under a microscope.

After being assembled into body forms never before seen in nature, the cells of the xenobots began working together to create ordered motion as guided by the computer design. The xenobots moved in circles and worked together to push tiny pellets into a central location. Head researcher Joshua Bongard says, "These are novel living machines. They're neither a traditional robot nor a known species of animal. It's a new class of artifact: a living, programmable organism." Researchers are hoping xenobots can be programmed to remove microplastics from the oceans or target medicine for delivery inside the human body.

Quoted in Jessie Yeung, "Meet the Xenobot: World's First Living, Self-Healing Robots Created from Frog Stem Cells," CNN, January 14, 2020. www.cnn.com.

physical capabilities. The Robot Nurse Bear turns people over in their beds, assists them when they stand up from chairs, and lifts them from the floor if they fall. The robot can transfer patients to wheelchairs or carry them from room to room. Nurse Brittany Hamstra writes, "An increasing elderly population paired with an insufficient amount of healthcare workers able to care for it makes revolutionary inventions like nurse robots incredibly helpful."[31]

Japanese robotics engineers have developed specialized robots such as the Robot Paro. This interactive robot uses machine learning to hold simple conversations to alleviate loneliness in elderly patients. Paro also can direct group entertainment programs. Robot Pepper, another type of robotic helper, is used to schedule appointments, explain medical information, and interpret data from machines that monitor vital functions. Pepper also reminds patients to exercise and take their medications.

Robots are appearing in other parts of the medical world, too. In the United States a robot named TUG is used in hospitals to transport medicines to patients and take specimens to laboratories. Another robot, called RIVA, helps pharmacies prepare IV (intravenous) bags and syringes. LUCAS is a machine built to perform cardiopulmonary resuscitation, an emergency procedure that involves compressing the chest to restore heartbeat in a person having a heart attack.

As with physicians, AI robots will not replace nurses but can help them do their jobs better while reducing mistakes. According to Hamstra:

> It is highly likely that artificial intelligence (AI) will be implemented in clinical settings rapidly and on global scale. . . . Robotic nurses will have the ability to [work with] patients in clinics, emergency departments, and via telehealth services in order to streamline care and provide standardized approaches to symptom management with far fewer resources. With AI as a tool to help treat and prevent illness, the number of hospital admissions and complications that result from lack of education or access to health services could decrease.[32]

Artificial intelligence will be used to discharge patients and monitor them via smartphone apps after they leave hospitals. If complications are detected, the patients will be readmitted. AI apps will help patients at home remember to take their medicine,

comply with treatment regimens, and check their vital signs. Apps will provide patients with information in any language and link them to videos about medicines, side effects, and disease management.

Editing and Sequencing Genes

While robotic doctors are helping cure the sick, artificial intelligence is also being used to combat cancer, viruses like HIV and COVID-19, and genetic diseases such as spina bifida. This research is focused on the human genome. The human genome contains DNA, a molecule that carries genetic instructions for the development, growth, function, and reproduction of an organism.

genome
The genetic material of an organism that contains DNA

Many illnesses people experience in their lifetime are related to their genetic makeup. But the human genome is made up of twenty thousand genes that combine into 3 billion DNA building blocks, which together determine each individual's unique physical makeup. In order to understand a person's genome, it must be sequenced, a process that determines the type of genetic information carried by each segment of DNA. Sequencing is a critical step to understanding which genes might cause specific genetic disorders. Sequencing can also identify mutations, or abnormal changes, in the genetic code. All cancers, for example, are a result of genetic mutations. When a gene sequence reveals problems, the genes can be "edited" to cure a disease. As science writer Aparna Vidyasagar explains, "The genomes of various organisms encode a series of messages and instructions within their DNA sequences. Genome editing involves changing those sequences, thereby changing the messages. This can be done by inserting a cut or break in the DNA and tricking a cell's natural DNA repair mechanisms into introducing the changes one wants."[33]

Scientists called geneticists perform research on genetic processes, conduct gene sequencing, and work to understand the

genetic data. This human-centered research effort is extremely time consuming. And there are only around sixteen hundred geneticists in the United States, according to the National Society of Genetic Counselors. With artificial intelligence systems, genetic sequencing and analysis can be done faster, cheaper, and more accurately. An AI technology called high-throughput sequencing allows the sequencing of an individual's DNA to occur in one day—a process that once took a decade. AI gene sequencing programs can distinguish small mutations in genes. Deep learning can also be used to analyze gene mutations in hundreds of thousands of cancer patients and compare them to an individual's genome to seek out and draw attention to such mutations. The AI can even predict a person's response to treatment. A physician can then prescribe the best course of action based on this huge pool of patient outcomes.

A microscopic digital image reveals the twisted strands of DNA molecules that make up the human genome. AI gene sequencing programs can help identify the location of gene mutations in cancer patients.

As research into AI and gene technology advances, scientists are expected to develop new pharmaceuticals that cure the sick by healing them on the genetic level. Newborns might one day be screened for diseases and pretreated before they are born. And the technology also holds promise for feeding the world as humanity faces the challenges of a changing climate. Genes might be edited to create drought-resistant, high-yield crops or modified yeasts that can produce biofuels to replace the fossil fuels that are in large part responsible for climate change.

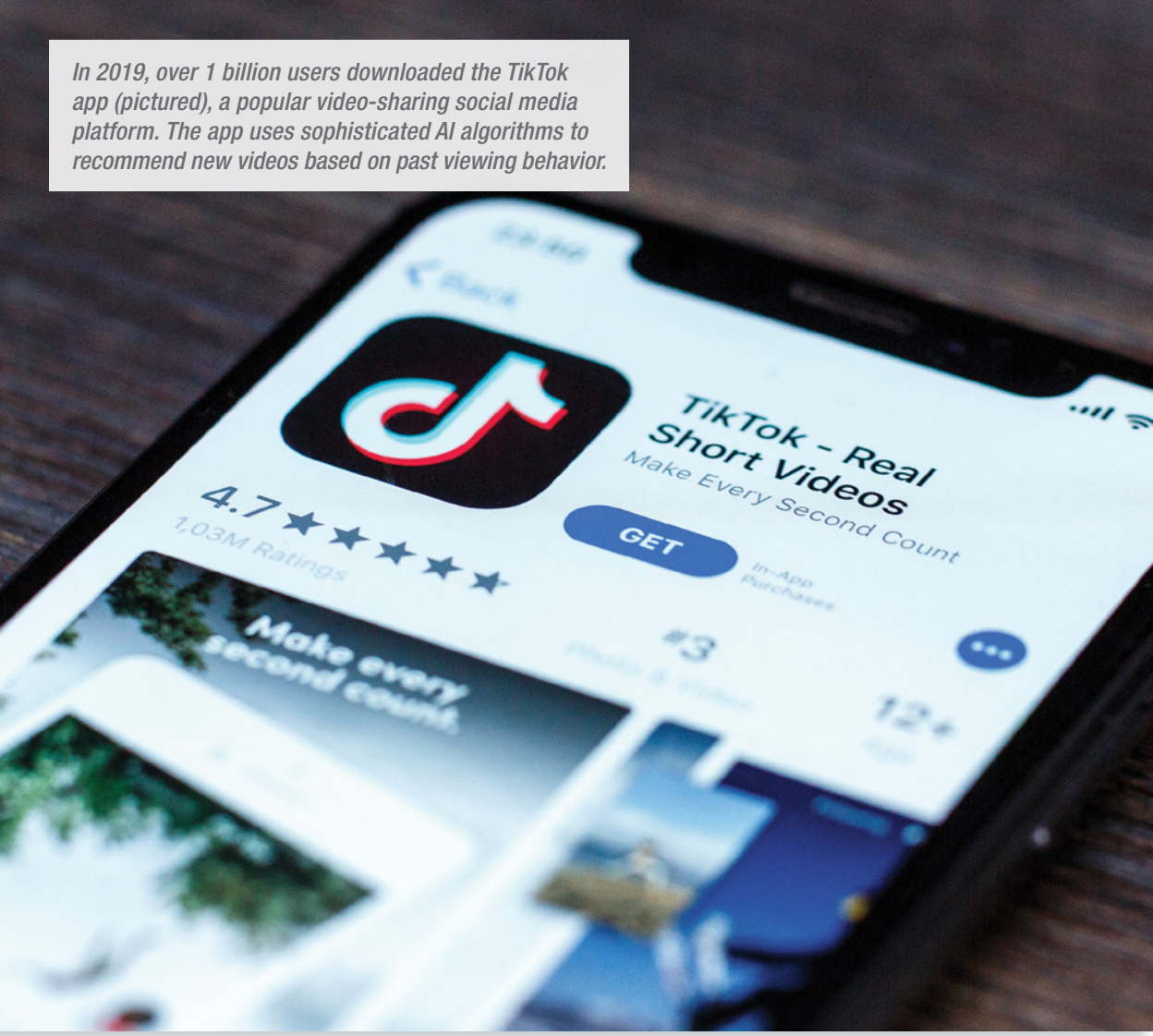
Scientists are pioneering new ways to grow food, cure disease, produce next-generation drugs, and provide robotic assistance to doctors. By combining biology with artificial intelligence, human health and health care are being transformed in ways that are just beginning to be understood.

The AI State of Surveillance

In 2019 TikTok was the most popular social media platform in the world. The TikTok app, which allows users to upload short homemade videos, was downloaded over 1 billion times and was available in 150 countries. TikTok helped make social media stars out of obscure users who soulfully lip-synched songs or performed silly stunts.

TikTok was designed in Beijing, China, by a tech company called ByteDance. The app uses sophisticated artificial intelligence algorithms to keep users scrolling for hours. The AI constantly recommends new videos based on past behavior. Algorithms screen out hate speech, sexual content, and other objectionable material. While the AI keeps TikTok wholesome, some reviewers believe there are downsides to the app. For example, journalist Ryan Broderick notes, "It aggressively mines user data, its videos require sound, it is largely oriented around a central recommendation algorithm instead of a network of friends and family, it emphasizes memes and challenges over individual influencers, and it continues to add addictive features to make it impossible to avoid bingeing."[34]

In 2019 TikTok's aggressive mining of data caught the attention of the Federal Trade Commission. The US consumer protection agency hit ByteDance with a $5.7 million fine for violating the Children's Online Privacy Protection Act, which limits collection of personal data on



In 2019, over 1 billion users downloaded the TikTok app (pictured), a popular video-sharing social media platform. The app uses sophisticated AI algorithms to recommend new videos based on past viewing behavior.

children under age thirteen. TikTok illegally swept up email addresses, names, schools, and other personal information on young users and refused to delete sensitive videos and other data when parents complained. In response, TikTok released an app for users under thirteen that it says does not collect personal data.

Chinese officials have not divulged what they do with the sweeping amount of information collected by TikTok. But according to a 2019 class-action lawsuit in the United States, "TikTok clandestinely has vacuumed up and transferred to servers in China vast quantities of private and personally-identifiable

user data that can be employed to identify, profile, and track the location and activities of users in the United States now and in the future."[35]

Social Credit Scores

Chinese companies like ByteDance would not exist without the express approval of China's ruling Communist Party. The government has the most extensive and advanced internet censorship policies in the world, known as the Great Firewall of China. ByteDance and other social media businesses are required to use AI to heavily police videos and remove those that criticize the government or contain controversial content. The Communist Party has access to all personal and financial records collected by TikTok in every country where the app is used. Nick Frisch, an Asian media scholar, finds this very disturbing. Frisch calls China a "surveillance state" where Chinese authorities use artificial intelligence to track everyone through smartphones, facial recognition, and other means. "Private [tech] corporations and the Communist Party's security apparatus have grown together, discovering how the same data sets can both cater to consumers and help [government officials] calibrate repression,"[36] Frisch argues.

Great Firewall
The term given to China's strict internet censorship system that employs human and artificial intelligence to monitor all online communications

A Chinese program called the Social Credit System provides an example of how data is used to repress people. The Social Credit System uses artificial intelligence to comb through government records, biometric data, and video images from over 200 million cameras located throughout the country. This data is used to assign almost every Chinese citizen a numbered score. The Social Credit System deducts points for minor infractions such as failing to pay a debt, breaking a traffic law, playing loud music, or even eating on public transportation. Those who cheat on school

tests, ignore the needs of their elderly parents, or publicly complain about the government are given lower scores. People who do good deeds, work hard, or run successful businesses have higher social credit scores. Those with good scores get promoted at work and are allowed to live in nicer apartments. Those with low scores are demoted, denied the right to travel, and forced to live in substandard housing.

The same AI-powered surveillance technology behind the Social Credit System is used to repress Uighurs (WEE-gurz), a Turkish-speaking Muslim minority in northwest China. Authorities monitor what language people speak at home, who they call outside the country, and how often they pray. Based on this information, officials say they can predict when an individual might engage in antigovernment activity. Those

A Uighur rights activist protests outside the Chinese Embassy in London, England, on January 5, 2020. Chinese authorities use AI-powered surveillance technology to monitor the personal activities of ethnic Uighurs and send those deemed as potential troublemakers to reeducation camps.

who refuse to speak Chinese or conform to government-approved social norms are sent to what are called reeducation camps, where they might be tortured or killed. The region where Uighurs live is described as an open-air prison due to the AI monitoring. As Uighur Human Rights Project director Nury Turkel explains:

> Trying to have a normal life as a Uighur is impossible. . . . Just imagine, while you're on your way to work, police [stop] you to scan your ID; forcing you to lift your chin while machines take your photo and you wait to find out if you can go. Imagine police take your phone and run [a] data scan and force you to install compulsory software allowing your phone calls and messages to be monitored. . . . What we're talking about is collective punishment of an ethnic group.[37]

Surveillance Capitalism

The Chinese are selling their total surveillance technology to authoritarian regimes around the world. They have exported their systems to fifty-three countries, including Pakistan, Venezuela, and Sudan. While this type of government-sponsored social and political control has not yet come to the United States, Americans are monitored by other powerful forces, often without their knowledge or consent.

Multibillion-dollar corporations like Google, Facebook, Twitter, and Amazon compile data on every search, like, posted photo, comment, and purchase made by users. The companies also cast a wide net for outside data, compiling information from apps used to manage health data, exercise regimens, finances, entertainment choices, and more. Facebook algorithms categorize users by what are called microexpressions. These tiny details in the position of the mouth, eyes, forehead, and other features are used to determine a user's emotional state. Facebook combines this information with other details that supposedly reveal the mind-set of the user. This data includes the number of exclamation points used

Micro-targeting Voters

The same type of behavioral targeting used to sell products is being harnessed by political entities hoping to sway voters. This issue made headlines in 2018 when the Federal Trade Commission fined Facebook $5 billion for mishandling users' personal information. The fine was based on an investigation that linked Facebook to a company called Cambridge Analytica, founded by billionaire Robert Mercer. Cambridge Analytica purchased the personal data on 87 million Facebook users intending to sell it to US election campaigns, including Donald Trump's and Ted Cruz's 2016 presidential runs, as well as to foreign governments. The company used information such as likes, internet activity, birthdays, and political preferences to micro-target users for digital ads and online surveys and to determine where candidates should travel to drum up support.

The fallout from the Cambridge Analytica scandal did little to slow the growth in AI firms seeking to use data analytics and micro-targeting to influence voters. In 2018 the Republican National Committee helped finance a new company called Genus AI, which, among other things, would collect data points for predictive modeling on millions of individual voters to communicate with them and ensure that they would vote. Harvard Business School professor Shoshana Zuboff is fearful of the power that AI can give to those who hope to sway elections. She states, "Now we know that any billionaire with enough money, who can buy the data, buy the machine intelligence capabilities, buy the skilled data scientists, they, too, can commandeer the public and infect and infiltrate and upend our democracy with the same methodologies that surveillance capitalism uses every single day."

Quoted in *Frontline*, "Transcript: In the Age of AI," PBS, November 18, 2019. www.pbs.org.

in an update and the pattern of likes inserted by a user across the platform. Facebook even uses AI to monitor heart rate data from its Instant Heart Rate app.

Artificial intelligence programs comb through this data and come up with fine-grained predictions of what kinds of ads users will click on and what kinds of products they will buy. This has led to what is called a behavioral prediction industry. Roger McNamee, an early investor in Facebook, insists, "Behavioral prediction

is about taking uncertainty out of life. Advertising and marketing are all about uncertainty—you never really know who's going to buy your product. Until now. . . . Private corporations have built a corporate surveillance state without our awareness or permission."[38]

Harvard Business School professor Shoshana Zuboff calls this economic model "surveillance capitalism."[39] Zuboff says surveillance capitalism was invented by Google. In the early 2000s Google considered information it collected about users' search terms, browsing histories, shopping preferences, and other online behavior to be useless. Programmers called it "digital exhaust."[40] But Google executives came to realize that they could boost profits by selling private information to advertisers. Zuboff notes, "We thought that we search Google, but now we understand that Google searches us."[41] The Google model was embraced by Facebook, Instagram, Twitter, and other social media giants and soon spread across a wide range of sectors, including entertainment, finance, education, and transportation. Zuboff describes how social media companies use every sliver of behavioral data produced by a customer:

> It's not just what you post, it's that you post. It's not just that you make plans to see your friends later. It's whether you say, "I'll see you later" or "I'll see you at 6:45." It's not just that you talk about the things that you have to do today; it's whether you simply rattle them on in a rambling paragraph or list them as bullet points. All of these tiny signals are the behavioral surplus that turns out to have immense predictive value.[42]

Ringing Out Privacy

Nothing exemplifies the concerns over surveillance capitalism better than the controversies surrounding a home-security device called Amazon Ring. The Ring, which attaches to door jambs, contains a doorbell; a high-definition, motion-detecting video camera;

and a microphone and speaker. Ring's selling point is that it helps prevent trespassing, home break-ins, and package theft. Whenever motion is detected near a user's door, Ring sends notifications and real-time video to an app on the user's smartphone—and to the Amazon cloud data storage system. But Ring does more than keep a digital eye out for criminal activity.

A study by the digital rights group Electronic Frontier Foundation (EFF) found that the Ring app collects data from users' phones and shares it with numerous marketing firms known as third-party trackers. These companies, such as AppsFlyer and Mixpanel, track user interactions with mobile apps and the web. Third-party trackers use AI to measure user engagement with apps and devices and sell this information to advertisers. AppsFlyer identifies every app on a user's phone, how the apps are configured, and even the order in which they appear on the screen. This information allows tracking companies to create a detailed fingerprint of each device. This digital fingerprint lets them know, among other things, when users open a game, join a Wi-Fi network, or post pictures to a social media website. Additionally, Ring trackers have access to biometric data, images of people's faces from photos, videos, and other sources. When describing information collected by Ring, EFF security engineer William Budington echoes Zuboff: "This surveillance device that can be used to surveil my neighbors is actually surveilling me now."[43]

third-party trackers
Companies that track, collect, and sell personal information about users' habits as they interact with apps and websites

According to Senator Edward J. Markey, Ring does more than surveil web activity. The device also violates the privacy and civil liberties of people caught on the camera. In 2019 Markey and four other senators launched an investigation into Ring cameras. They discovered that the cameras record people passing on the street, along with those who approach the front door for

The Amazon Ring video doorbell (pictured) allows users to monitor the entrance to their home remotely, using a smartphone app. While the device can alert homeowners to criminal activity, the app also collects personal data and shares it with advertising companies.

any reason. For example, Ring reported that on Halloween 2019 its doorbell buttons were pressed 15.8 million times. The company did not say how many images it holds of children who were recorded while trick-or-treating.

Ring shares images taken without permission with more than four hundred police departments around the country. These departments are part of a Ring program called Neighborhood Portal, which provides police with a map to all Ring cameras in a neighborhood. While it is illegal for police to access images from a personal device without a search warrant, Ring images are stored on Amazon servers. Police can download them without a warrant and without providing evidence of a crime. In a letter addressed to Amazon CEO Jeff Bezos, Markey expressed concern that Ring was planning to add facial recognition technology to its doorbell cameras: “With the potential to flag certain individuals

Activists, Amazon, and Police Partnerships

In 2019 more than thirty civil rights organizations published an open letter urging lawmakers to end the partnerships between Amazon Ring and local police departments. The organizations were concerned that videos collected by the Ring doorbell security device violate privacy rights and can be used by authorities for racial profiling. The letter from the National Immigration Law Center, Color of Change, Project on Government Oversight, and others reads in part:

> With no oversight and accountability, Amazon's technology creates a seamless and easily automated experience for police to request and access footage without a warrant, and then store it indefinitely. . . . Once collected, stored footage can be used by law enforcement to conduct facial recognition searches, target protesters exercising their First Amendment rights, teenagers for minor drug possession, or shared with other agencies like ICE [Immigration and Customs Enforcement] or the FBI. . . . These live feeds provide surveillance on millions of American families—from a baby in their crib to someone walking their dog to a neighbor playing with young children in their yard—and other bystanders that don't know they are being filmed and haven't given their consent. . . .
>
> Amazon Ring partnerships with police departments threaten civil liberties, privacy and civil rights, and exist without oversight or accountability. . . . To that end, we call on mayors and city councils to require police departments to cancel any and all existing Amazon Ring partnerships, and to pass surveillance oversight ordinances that will deter police departments from entering into such agreements in the future.

Fight for the Future et al., "Open Letter Calling on Elected Officials to Stop Amazon's Doorbell Surveillance Partnerships with Police," Fight for the Future, October 7, 2019. www.fightforthefuture.org.

as suspicious based on their biometric information . . . a product like this has the potential to catalyze racial profiling and harm people of color."[44]

Markey notes that facial recognition technology is imperfect and often misidentifies African Americans, Latinos, and other

people of color. And this can have implications when Amazon uses the videos to promote Ring. According to Matthew Guariglia of the EFF, faces of alleged wrongdoers have appeared in Ring advertisements. "Amazon harvested pictures of people's faces and posted them alongside accusations that they were guilty of a crime, without consulting the person pictured or the owners of the cameras,"[45] Guariglia claims.

Crime has steadily decreased in recent decades and is at historically low levels in many places. But as in China, major American tech companies are partnering with police to monitor citizen activities online and off. The EFF worries that this partnership lacks public oversight and transparency, which threatens everyone's privacy. According to Guariglia:

> It also may chill the First Amendment rights of political canvassers and community organizers who spread their messages door-to-door, and contribute to the unfair racial profiling of our minority neighbors and visitors. Even if you chose not to put a camera on your front door, video footage of your comings and goings might easily be accessed and used by your neighbors, the police, and Amazon itself.[46]

From the Personal to the Political

While privacy advocates worry about digital surveillance at the front door, they are also concerned about what is happening inside the home, in living rooms, kitchens, and bedrooms. In 2019 more than 100 million Americans owned an Amazon Echo, with its Alexa virtual assistant, while millions more had Google Home devices. These AI-powered voice-recognition assistants do more than play music, provide weather forecasts, and offer traffic updates. The devices learn to compare the vocal tones of users over time. They can detect sneezes, a wobble in the voice, and even emotions like sadness and anger. This information is ostensibly used to recommend products, such as allergy medications or

sleeping pills. As Zuboff explains, this is "microbehavioral targeting that is directed toward individuals based on intimate, detailed understanding of personalities."[47]

Most people go about their day assuming that they are private citizens engaging in private activities. But tech corporations are vacuuming up every tweet, purchase, photo, video, GPS-enabled trip, email, browser history, and more. Billions of people have been creating trillions of data points for decades, and this information has been sliced up into categories by artificial intelligence that provides a fairly accurate picture of every person's habits and beliefs.

microbehavioral targeting
A method of employing internet user information to target marketing or political campaigns based on individual tastes and habits

When digital information is used to sell people consumer products, it can seem like a harmless act. But when the data is used to sway elections or harass political dissidents, the issue of personal privacy becomes very important. People value the right to be left alone and not have the government or corporate entities interfering in their lives. But even if people closed all their internet accounts and threw away their smartphones, they would still be watched by street corner video cameras and tracked by apps built into their cars. As it turns out, digital exhaust is worth trillions of dollars. As long as money and power are to be gained by monitoring digital devices, privacy rights will take a backseat to the search engines calibrated to search the searchers.

Lethal AI Weapons

In 2019 the US Air Force used an F-35 fighter jet in combat for the first time. The $82 million jet conducted an air strike on a tunnel network in Iraq that was built by the terrorist network ISIS. The F-35 relies on high-end sensors and an artificial intelligence network to make assessments of enemy positions and to target weapons. Artificial intelligence conducts flight checklists and transmits aircraft health and maintenance information to ground crews. Military journalist Kris Osborn explains, "The F-35s so-called 'sensor fusion' uses computer algorithms to acquire, distill, organize and present otherwise disparate pieces of intelligence into a single picture for the pilot."[48]

In 2020 the air force was working to pair the F-35 sensor-fusion system with unmanned aerial vehicles called drone wingmen. While most military drones are flown by ground crews, the drone wingmen will be controlled by the pilot of the F-35, aided by artificial intelligence. There are plans to use drone wingmen as flying weapons trucks, to carry spare missiles. The wingmen will be flown in small groups to perform reconnaissance and targeting missions, flying into dangerous areas ahead of a fighter jet to assess enemy positions. This will reduce threats to the pilot. In fast-moving combat situations, the drone wingmen can move into position to provide a weaponized, protective barrier around an F-35.

reconnaissance
Military observation of a region to locate an enemy or determine strategic features

The Battlefield of the Future

While artificial intelligence is most often associated with big tech companies like Google, the tech revolution would never have happened without funding by the US Department of Defense. In 1966 a secretive Defense Department entity called the Defense Advanced Research Projects Agency (DARPA) provided grants to develop ELIZA, the first interactive speech program. DARPA dollars paid for the research that launched the internet in 1969 and led to the development of GPS technology in 1973. The agency also spent $1 billion on autonomous vehicle research in 1983.

By 2018 the most talented machine learning engineers were not working for DARPA. They were employed by Google, Oracle, Amazon, IBM, and other tech companies. This led the Pentagon to create the Joint Artificial Intelligence Center (JAIC), an agency that partners with these private tech companies. JAIC's goal is to rapidly integrate artificial intelligence and cloud computing power into all areas of military operations. The head of JAIC, Lieutenant General Jack Shanahan, described future wars as "algorithms vs. algorithms,"[49] with the fighters who deploy the best algorithms emerging victorious on the battlefield.

A Lockheed Martin F-35 fighter jet performs at an air show in Fairford, England. The F-35 relies on high-end sensors and an artificial intelligence network to make assessments of enemy positions and to target weapons.

As the F-35 program demonstrates, military strategists see many advantages in combining AI with drones, which already use powerful software programs to map flight paths, control speed and altitude, and navigate from one point to another without human control. Military drones can be large, such as the air force's MQ-1 Predator, which has a wingspan of more than 48 feet (14.6 m). Tiny drones, known as "micro," "bug," or "nano" drones, might be around 1 by 4 inches (2.5 by 10 cm) and weigh little more than half an ounce (14 grams).

Killer Drones

Whatever the size, all drones are equipped with video cameras that can use machine learning technology combined with facial recognition software to identify people and objects. A military program called Project Maven was established to use this drone video data to track and spy on targets without human involvement. Kevin Berce, business development manager at the tech hardware company Nvidia, explains:

> [The Department of Defense] has a huge influx of video coming in. Inside all this video are nuggets of intelligence, but there's too much of it for analysts to ingest and digest to then make an intelligence decision on. Machine learning is going to help tell the analysts where to look. If you're looking for a white truck, why spend time looking at hours of video where there's no white truck? Let's just give the analysts the video where the white truck is.[50]

Maven algorithms could also be used to create what are called lethal autonomous weapons systems (LAWS)—drones that can assassinate people. In theory, these autonomous robots could use facial recognition to identify the occupant of the white truck in Berce's example. The drone could discover that the truck's occupant is a wanted terrorist. Without human intervention it could launch a missile or drop a bomb to kill the person in the truck. As

An MQ-9 Reaper drone flies over the Nevada Test and Training Range. All drones are equipped with video cameras that can combine machine learning technology and facial recognition software to identify people and objects during military missions.

journalist Annie Jacobsen explains, "The nontechnical term for an autonomous drone is a hunter-killer robot, a robotic system 'intelligent' enough to be shown a photograph of a person and told to return when the target has been killed."[51]

As of 2020 there were no LAWS being used anywhere in the world. But according to the antiwar organization PAX, over thirty global arms manufacturers were developing lethal autonomous weapons systems. In the United States military regulations require "commanders and operators to exercise appropriate levels of human judgment over the use of force,"[52] according to the Congressional Research Service. This means that no one would be killed by an autonomous weapon without prior approval of a human observer. However, the military has no restrictions that prohibit the development of LAWS. And other countries that are engaged in the AI arms race with the United States, including Russia and China, have no known rules governing the use of LAWS. Shanahan notes, "China and Russia didn't hold public hearings on the ethical use of their AI and I never expect them to."[53]

There are few doubts that autonomous drones of the future will be enabled to learn the terrain of a battlefield, identify and kill targets, and even battle other AI drones. According to military analyst P.W. Singer, tens of thousands of LAWS from nations large and small will be operating by 2040. And the computers that control the drones will be "close to a billion times more powerful . . . than today,"[54] says Singer.

Flying Minefields

A new generation of battlefield weapons is being built to operate cooperatively in groups called swarms. While it currently takes at least one pilot to operate a drone, an AI-enabled swarm of drones could be controlled by a single person or could work autonomously to learn and perform tasks. Singer believes it will be the latter: "The swarm idea inherently drives you toward autonomy. The whole idea of a swarm is not just that it's a lot of them, but a lot of them working together, sharing information across the swarm."[55]

The US Air Force and US Marine Corps are working to pair Maven algorithms with drone swarms that would closely monitor up to 40 square miles (103 sq. km) of territory at once. DARPA is also working on swarm drone technology. In 2019 the agency ran a field test using an autonomous drone swarm to demonstrate the capabilities of intelligent machines in urban warfare settings. A mock hostage rescue mission was conducted in an uninhabited section of a Georgia military training base. The mission was part of DARPA's OFFensive Swarm-Enabled Tactics (OFFSET) program, described by the agency: "[The] program envisions future small-unit infantry forces using swarms comprising upwards of 250 unmanned aircraft systems (UASs) and/or unmanned ground systems [robots] to accomplish diverse missions in complex urban environments."[56] During the mock rescue, DARPA drones flew through the air, analyzed a two-block area, located a hostage, and surrounded and secured the building. Each drone was programmed with artificial intelligence, allowing it to collect and analyze physical details of the environment and move and make

decisions autonomously. A dedicated swarm cloud network coordinated actions and shared information between drones.

Another DARPA program, called Squad X, is designed to aid soldiers in the field and help them overcome what is called the fog of war. This phrase describes the uncertainty about their surroundings that soldiers sometimes experience in battle. The AI-powered drones and robots of Squad X are designed to gather and transmit information about battlefield conditions to tablet computers held by soldiers. The drones can also disrupt enemy communications by shutting down radio frequencies and cyber domains. Another system that was under development in 2020 allows drone swarms to locate targets and engage them. Tech journalist David Hambling explains the advantages of using what he calls swarm troopers to fight battles:

> A swarm of armed drones is like a flying minefield. The individual elements may not be that dangerous, but they are so numerous that they are impossible to defeat. They can be disabled one by one, but the cumulative risk makes it safer to avoid them than to try to destroy them all. Minefields on land may be avoided; the flying minefield goes anywhere. When it strikes targets on the ground the swarm can overwhelm any existing opposition by sheer numbers of intelligently-targeted warheads.[57]

In 2017 a US Navy program called Low-Cost UAV Swarming Technology (LOCUST) was among the first in the world to test swarm troopers. The LOCUST system consists of a launcher comprising several tubes, which can dispatch drones in rapid succession. The launcher is small enough to be mounted on a vehicle and can also be attached to an airplane or ship. The launcher works with small drones such as the Coyote, which is 3 feet (91 cm) long.

Coyote drones can be equipped with warheads and fly at speeds approaching 100 miles per hour (161 kph). When numer-

Campaign to Stop Killer Robots

In 2018 thousands of tech workers at Google signed a petition protesting the company's partnership with the US military. One of those workers, software engineer Laura Nolan, resigned after being assigned to a project that would use Google artificial intelligence and facial recognition systems to enhance the capabilities of autonomous drones. Nolen calls such drones killer robots and says they should be outlawed by international treaties. Nolan is part of a group called the Campaign to Stop Killer Robots that has worked with officials at the United Nations to help them understand the dangers posed by AI weapons. According to Nolan:

> The likelihood of a disaster is in proportion to how many of these machines will be in a particular area at once. What you are looking at are possible atrocities and unlawful killings . . . especially if hundreds or thousands of these machines are deployed. There could be large-scale accidents because these things will start to behave in unexpected ways. Which is why any advanced weapons systems should be subject to meaningful human control, otherwise they have to be banned because they are far too unpredictable and dangerous. . . .
>
> These autonomous weapons . . . are an ethical as well as a technological step change in warfare. Very few people are talking about this but if we are not careful one or more of these weapons, these killer robots, could accidentally start a flash war, destroy a nuclear power station and cause mass atrocities.

Quoted in Henry McDonald, "Ex-Google Worker Fears 'Killer Robots' Could Cause Mass Atrocities," *The Guardian* (Manchester), September 15, 2019. www.theguardian.com.

ous Coyotes are airborne at once, they communicate with one another and fly to targets in a synchronized V formation, like a flock of geese. The autonomous drones can turn into an insect-like swarm when encountering enemy troops, vehicles, and boats. In patrol mode, swarms of Coyotes can work together to protect navy equipment and personnel.

In a similar but unrelated program, the navy was developing drones called Close-In Covert Autonomous Disposable Aircraft (CICADA). These hand-sized micro-drones are undetectable by radar. They can be created inexpensively with a 3-D printer, which makes solid three-dimensional objects from a fine plastic dust called PMMA.

In a 2019 test, hundreds of CICADAs were seeded, or dropped, by a large drone flying at an altitude of 50,000 feet (15,240 m). The autonomous micro-drones avoided cliffs, trees, and other obstacles to land within 15 feet (4.6 m) of a target. The navy believes these tiny, disposable aircraft could allow military surveillance of dense jungle areas without sending a human pilot into enemy territory. The CICADAs might be used to locate enemy submarines and could also be distributed to other branches of the military to pick up the spoken orders of enemy officers or to monitor troop movements behind enemy lines.

The AI Battleground

The United States faces a unique challenge when it comes to developing next-generation AI weapons. The technology often comes from private corporations, and workers might object to their research being weaponized. This proved to be a problem when Google and the Pentagon teamed up for Project Maven. In 2018 three thousand Google employees signed a petition to protest the military use of company technology. The objections led Google to forbid the use of its AI research on weapons. Google continues to work with the Pentagon on other systems.

There are no such barriers to collaborations between the military and the private sector in China. And the Chinese are moving quickly to add AI and autonomy to military weapons systems, including robots, drones, missiles, and nuclear weapons systems. In 2019 Zeng Yi, an executive at a major Chinese defense company, explained his vision for fighting wars: “In future battlegrounds, there will be no people fighting. . . . [Military use of AI is] inevitable. We are sure about the direction and that this is the fu-

A model of China's Blowfish A2 drone was displayed at the 2019 International Aviation and Space Salon in Moscow, Russia. Considered one of the most fearsome military weapons in production, the 84-pound, 6-foot-long helicopter boasts a machine gun hanging from its undercarriage.

ture. Mechanized equipment is just like the hand of the human body. In future intelligent wars, AI systems will be just like the brain of the human body."[58]

The Blowfish A2 drone, produced by the Chinese company Ziyan, is one of the most fearsome weapons in production. The 84-pound (38 kg) machine looks like something out of a science fiction film—a 6-foot-long (1.8 m) futuristic helicopter with a machine gun hanging from the undercarriage. The Blowfish can also be outfitted with explosive mortar shells, a grenade launcher, and missiles. It can even carry out a suicide attack. The Blowfish A2, and its successor, the A3, can fly at a speed of 80 miles per hour (129 kph). With the push of a single button, the drones can take off autonomously in swarms of ten. The swarm can find its way to a designated target, carry out a mission, return to base, and land automatically. In 2019 China was selling the autonomous gunships to governments in Pakistan and Saudi Arabia.

China tripled its military budget from 2007 to 2017 and placed a major focus on AI research. And Chinese officials believe they are ready to leapfrog the United States when it comes to adapting AI military technology. While the United States spends billions of dollars on major programs like the F-35, China is developing disruptive new systems. For example, Chinese researchers are designing autonomous, low-cost, long-range submarines that can travel in swarms and launch torpedoes. National security expert Gregory C. Allen writes, "China believes these systems will be a cheap and effective means of threatening U.S. aircraft carrier battlegroups and an alternative path to projecting Chinese power at range. In general, China sees military AI [research and development] as a cheaper, easier path to threatening America's source of military power than developing Chinese equivalents of American systems."[59]

Weaponizing Deepfakes

Low-cost military applications of artificial intelligence do not necessarily need to involve submarines, drones, and machine guns. The national security of a nation can be threatened by deepfakes, a term that mixes the words *deep learning* and *fake media*. Deepfakes are videos that are manipulated by machine learning algorithms and facial mapping software to create a false impression among viewers. Deepfakes can present convincing images and soundtracks of politicians, CEOs, and celebrities making false statements or even participating in staged acts. Facebook CEO Mark Zuckerberg said his company would not delete demonstrably false videos. In an ironic twist, artists Bill Posters and Daniel Howe created a convincing deepfake of Zuckerberg stating, "[I have] total control of billions of people's stolen data, all their secrets, their lives, their futures."[60]

deepfake
Media in which a person in an existing video is replaced by someone else's likeness

Dangerous Deepfakes

In 2019 researchers at Samsung created artificial intelligence software that could create a realistic deepfake video from a single photograph. The Samsung team released a five-minute YouTube video that demonstrates the capabilities of what it called a facial mapping model. The system works by creating a model of a person's face based on thousands of images available on the internet. The software uses these images to create a realistic avatar using exact facial measures such as the size and location of the eyes, nose, and mouth. A generator network maps what are called facial landmarks to accurately capture a person's range of expression. In a third step, a discriminator network positions the avatar onto the facial landmarks of an individual in the target video.

While Samsung claims its new AI tool is fun and entertaining, it can be used for malicious purposes such as blackmail and political slander. At a US Senate hearing in 2018, Senator Marco Rubio stated, "A foreign intelligence agency could use deep fakes to produce a fake video of an American politician using a racial epithet or taking a bribe or anything of that nature. . . . Imagine a compelling video like this produced on the eve of an election or a few days before a major public policy decision. . . . I believe that this is the next wave of attacks against America and western democracies."

Marco Rubio, "Video Transcript: At Intelligence Committee Hearing, Rubio Raises Threat Chinese Telecommunications Firms Pose to U.S. National Security," Marco Rubio, US Senator for Florida, May 15, 2018. www.rubio.senate.gov.

While making fun of popular figures might seem harmless, foolproof fabrications can be weaponized for propaganda purposes. And the threat posed by such deepfakes is being taken seriously by DARPA, which spent $68 million in 2019 to develop detection technology to determine whether a video or soundtrack had been manipulated. But many feel detection programs will be useless in fighting disinformation campaigns that use deepfake videos. These videos often go viral and can thus damage someone's reputation despite being debunked later. As Rachel Thomas, cofounder of the machine learning lab Fast.

ai, explains, “Fakes . . . don’t have to be that compelling to still have an impact. We are these social creatures that end up going with the crowd into seeing what the other people are seeing. It would not be that hard for a bad actor to have [a major] influence on public conversation.”[61]

Artificial intelligence will continue to play a major role in war and politics for years to come. Whether people will be able to control autonomous weapons and deepfake media remains to be seen. The late renowned physicist Stephen Hawking concluded in 2018, “A super-intelligent AI will be extremely good at accomplishing its goals, and if those goals aren’t aligned with ours, we’re in trouble.”[62]

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Allen Institute for AI (www.allenai.org). This organization was founded by Microsoft cofounder Paul Allen. The institute's website features programs, projects, research papers, and news articles that explain how AI can have a positive impact on humanity.

Association for the Advancement of Artificial Intelligence (www.aaai.org). This international scientific association promotes research in the responsible use of AI, with a focus on public education, training, and research. The group publishes *AI Magazine*, which features articles on AI in the classroom and robot competitions.

Campaign to Stop Killer Robots (www.stopkillerrobots.org). This organization founded by engineers, programmers, and robotics scientists lobbies the United Nations and other entities to stop the spread of fully autonomous weapons. The website features news articles, research papers, and upcoming events that warn of the dangers of killer robots.

Defense Advanced Research Projects Agency (DARPA) (www.darpa.mil). The DARPA website contains information about the latest artificial intelligence breakthroughs in national security. The agency helped to fund the invention of the internet offers research grants and hosts student partnership programs and team challenges.

Partnership on AI (www.partnershiponai.org). The original name of the organization, Artificial Intelligence to Benefit People and Society, explains its purpose. Founded by Amazon, Facebook, DeepMind, Microsoft, and IBM, the website features blogs, news, and research dedicated to responsible use of AI.

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